from 8 to 12, the latter being perfect. On rare occasions it drops to 6, which is about the best we have in Cambridge, Mass. At the approach of a hurricane the "seeing" drops to 4 and sometimes to 3.

This fact was first noted in August, 1899, at the time of the passage of a severe hurricane to the north of Haiti. The center was at a distance of 450 miles and did not reach Jamaica (Annals, Harvard Observatory, v. 61, p. 21). The next observation was from our present station in Mandeville in 1912. On the evening of November 9 the "seeing" had been rather poor, 7, but at midnight it suddenly dropped to 3. After that we had continuously cloudy nights and no observations were secured for two weeks. The disturbance was not announced by the Weather Bureau until November 12, but on the 9th the center was probably located about 500 miles to the south of us. On November 15, 16, and 17 we had 19.70 inches of rain, but the center did not pass us until the 18th. It came within 25 miles of us, and the maximum velocity of the wind was estimated at 55 miles.

The third hurricane observed occurred in August of the present year. On the evening of the 10th the seeing in the zenith was noted as 11. The next afternoon the highest maximum temperature in three years was recorded here, 88.7°F. and we were informed that the Weather Bureau indicated a disturbance south of Porto Rico, some 800 miles to the east of us. Since the hurricane center is always small, the chance that it will strike us is not very great. We do not consider its mere proximity as a very dangerous phenomenon, either to ourselves personally or to our instruments, but it is certainly a nuisance. It not only always damages our bananas and shrubs, but it interferes for a number of days with our observations. It was therefore with some considerable interest that we turned our telescope to the zenith that evening to look at the indications. There was no mistaking them, the seeing had dropped to 4, and the image was constantly fluctuating in both size and shape. Yet to the naked eye the stars appeared as steady as usual, no twinkling being visible at a greater altitude than 30°. The center passed 50 miles to the north of us at 3 a. m. of August 13. The maximum wind velocity was estimated at 40 miles, but it may have been rather higher in the nighttime. The total rainfall on the 12th, 13th, and 14th was 15.85 inches.

Our fourth hurricane came in September. On the night of the 21st the seeing on the moon was recorded as 8. Doubtless in the zenith it would have been higher, perhaps 10. The next night at 8 o'clock it was reduced to 5, and at 4 o'clock the following morning to 4. There was no doubt but that there was trouble again to the east of us. The distance of the center at this time was 750 miles. We focused on the air currents, and found them coming from the east 20° south, rather slowly, the lines occasionally breaking into dots. They came pretty nearly direct from the storm center. The distance between the lines was 1.5 to 2 inches. It was a very dry night, with the stars twinkling up to an altitude of 50°. The next afternoon, September 23, we received a Government report of a disturbance to the eastward. In the evening the seeing was the same, 4, but the bands now moved more swiftly and were farther apart, about 3 inches. Their direction was the same. The current therefore now came from slightly to the north of the center. The stars twinkled up to an altitude of 45°. There was a good deal of cloud after 9 p. m. September 24 was a rainy evening, but we got a few glimpses of the stars between the hurrying clouds. The direction of the bands had now shifted to east 6° south, which was parallel to the motion of the center, and their velocity was so high that we could not tell whether they were traveling east or west. Their breadth had increased to 5 inches. The wind came in gusts from the east, estimated at 8 miles. The center was now some 200 miles to the southeast of us.

Our telescope is of 11 inches aperture, furnished with a diagonal eyepiece for zenith observations. When the eyepiece was pulled out 5 millimeters beyond the focus, the air currents were easily seen, and even at 2 millimeters they were visible. This latter would correspond to an altitude of 6 miles. The lowest altitude observed was 1.5 miles. The direction seemed to be the same at both altitudes, but observations could only be made through occasional holes in the clouds, while it was not desirable to expose the telescope to the frequent showers. Observations were therefore somewhat imperfect.

The writer has received a tracing of the path of this hurricane through the kindness of the Government meteorologist, Mr. Maxwell Hall.[1] The center passed 90 miles to the south of us early September 25. The wind was not estimated higher here than 25 miles. The total rainfall on September 25, 26, and 27 was 18.39 inches, 9.90 inches falling on the first date, which is our record for the past three years.

22° HALO WITH UPPER AND LOWER TANGENT ARCS.

By C. G. ANDRUS, Assistant Observer.

[Dated: Weather Bureau, Richmond, Va., Oct. 26, 1915.]

The cirro-stratus clouds which covered the sky at noon October 26, 1915, at Richmond, Va., were the occasion for a complete solar halo in combination with the upper and lower tangent arcs (*c* and *d?*, fig. 1) that are sometimes observed with this halo. The radius of the halo (as measured with the device described in this REVIEW, May, 1915, p. 214) was 21° 30′. The lower summit resembled a parhelion and was of a bright, whitish color, but of little lateral extent. The upper summit was longer, of better colors, and had a flattening effect on the appearance of the halo at this point.

At 12:50 p. m. (75th mer. time) there was little change in arrangement, but the colors were more brilliant.

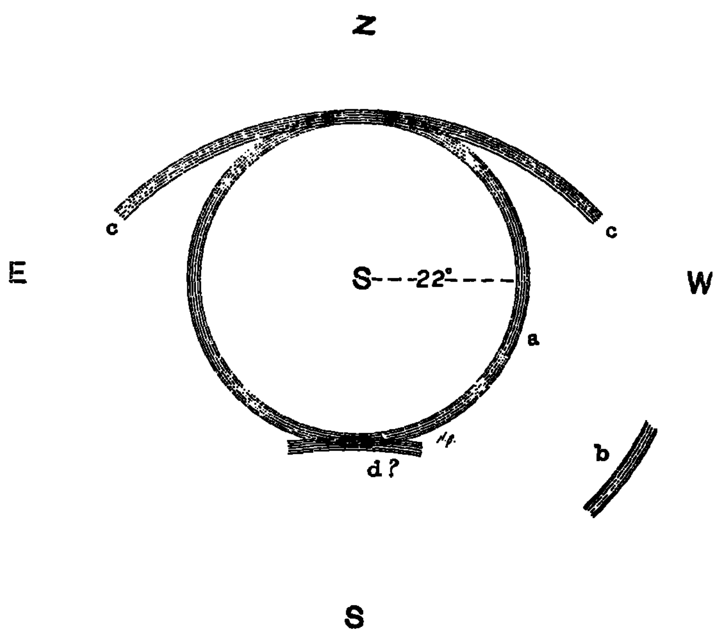

FIG. 1.—22°-halo *a* and tangent arcs *c* and *d?*; with a fragment of the 46°-halo (?), *b*, seen at Richmond, Va., 1915, 26 Oct., 1:50 p. m. (75th M. S. T.).

At 1:50 p. m. the halo had faded noticeably while the tangent arcs had brightened and lengthened, especially

[1] Details of the experience of Jamaica during these hurricanes of August and September, 1915, will be found in the Jamaica Weather Report, Nos. 445, 446, and 447.

the upper one. The distance from c to the upper summit (see drawing) was about 75°; from c to the sun, 30° approximately. For a few moments at this time a faint, colored arc (b in fig. 1) was visible in the southwest sky at about 45° distance from the sun and apparently concentric to the halo; it displayed the colors of the spectrum in good definition with the red appearing on the side nearer the sun.

The halo and tangent arcs continued visible until 3:10 p. m., when a covering of alto-cumulus clouds had obscured the whole phenomenon.

EXPERIMENT ON SUNSET COLORS.[1]

By F. W. JORDAN.

[Reprinted from Science Abstracts, Sec. A, Oct. 25, 1915, §1403.]

The purity of color in a diffraction halo[2] depends essentially on the size of the condensed droplets. The author describes a simple experiment in which the motion and distribution of the different-sized water droplets in a cloud are partially controlled. The colors obtained on illuminating the cloud with sunlight are comparable with those of soap films and present the features of sunset colors. It is concluded that some of the brilliancy and extensiveness of sunset colors is due to a quiescent state or regular motion of the clouds or mist at sunset and also to a distribution into layers of droplets of nearly uniform size.—*T. Harris.*

HALO OF MAY 20, 1915, ANALYZED.

By Prof. CHARLES SHELDON HASTINGS.

[Dated: Sloane Laboratory, Yale University, Oct. 25, 1915.]

[Early in September of this year Mr. A. M. Comey, of the Eastern Laboratory, Du Pont Powder Co., Chester, Pa., sent this Bureau two very interesting photographs of the solar halo of May 20, 1915, as seen at Chester, Pa. (lat. 39° 50′ N.; long. 75° 20′ W.). The first view, shown in figure 1, was taken at 11:15 a. m. (75th mer.) with a Zeiss wide-angle lens of Series 5, using stop 64 and 1/100 second exposure. The second photograph was taken at 11:45 a. m., and showed the features reproduced in figure 3. In this REVIEW for May, 1915, we presented a large photograph of the corresponding halo seen at New Haven, Conn.; Mr. Comey's photographs are of additional interest, since they record the parhelic circle as well as the circumscribed halo of 22°. Unfortunately these photographs were unable to record the brilliantly colored arc of the 46°-halo, reported from both localities, although figure 3 was extensive enough to have included it.

Both photographs from Chester have been studied and analyzed by Prof. Hastings and the results are communicated below.—C. A., jr.]

A careful study of Mr. Comey's photographs of the halo of May 20 yields a remarkable amount of exact conclusions. These I shall endeavor to make clear.

It is to be observed that the photographs are, in a sense, not true pictures of what one might have seen, but are in reality a projection on a plane of lines in a concave sky—linear dimensions, not angles, are recorded. Did we know the exact focal length of the lens used it would be easy to deduce the angles from the linear dimensions. Nevertheless, it is possible to deduce the focal length from the pictures themselves with all requisite precision.

Focal length of camera.

We are justified in assuming that the middle of the plate is in the axis of the camera as employed. If this is so, it is clear that all great circles passing through the corresponding point in the sky would appear in the photograph as straight lines in this point, which we may designate by P. The angular distance from P to any point on one of these lines is given by the equation

$$F \tan \alpha = d,$$

where d is the measured distance by any scale and F is the focal length in the same units. Moreover, according to any theory of halos the angular distance separating the highest point of the halo from the lowest point is very nearly 44 degrees; or for a photographic view, in which violet light is most effective, we may estimate this distance as equal to 44.6 degrees. These considerations and direct measurement of the photograph give us the following set of equations for the photograph of figure 1:

$F \tan \alpha = 1.48$ in., $F \tan \beta = -4.15$ in., $\alpha - \beta = 44.6°$.

The corresponding equations for the photograph of figure 3 are as follows:

$F \tan \alpha = 4.30$ in., $F \tan \beta = -0.64$ in., $\alpha - \beta = 44.6°$.

The only uncertainty here depends on our assumption as to the adjustment of the camera and my own estimate as to the position of the beginning of the brightest portion of the ring. The solution of the first equations gives $F = 5.54$ in. and of the second $F = 5.51$ in., values in sufficiently close agreement.

Circumscribed halo and parhelic circles.

The position of the zenith in figure 2 is pretty accurately fixed, since the parhelic circle is well defined and that portion near the sun is so close to P that it is little distorted. My estimate from this plate makes the zenith distance of the sun equal to 26.1°. The zenith distance of the sun at the time the second photograph was taken is not so easily found, chiefly because of the faintness of the image of the parhelic circle. My conclusion from measures freed from distortion is a zenith distance in this case of 21.5°, which can not be far from the truth.

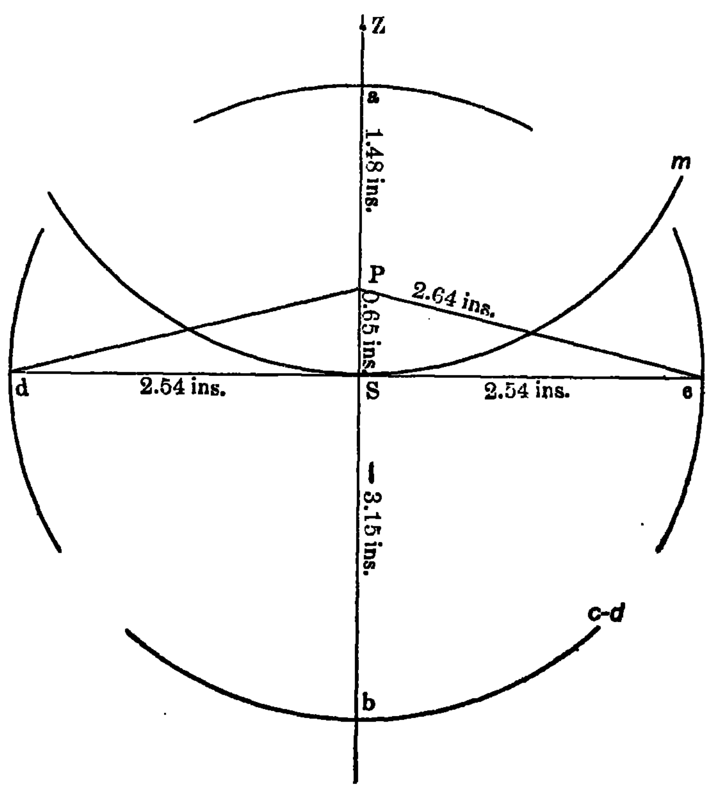

FIG. 2.—Analysis, by Prof. C. S. Hastings, of the original large print reproduced on a smaller scale in fig. 1. The dimensions refer to those of the original print.

The horizontal semidiameter, Sc, of the circumscribed halo is found as follows:

Angular distance P to c (or d) is 25.5°, since $F \tan 25.5° = 2.64$ inches.

Angular distance P to S is 6.7°, since $F \tan 6.7° = 0.65$ inch.

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[1] Nature (London), July 29, 1915, 95:590-591

[2] Better termed "corona."—C. A., jr.